IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

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First Named Inventor	:	Kazuhiko HONDA
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Title	:	Method of Printing Label on Optical Disk, Optical Disk Unit, and Optical Disk

SUBMISSION OF VERIFIED ENGLISH TRANSLATION OF PRIOIRTY DOCUMENT PURSUANT TO 37 C.F.R. 1.55

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

The benefit of the filing date of prior foreign application JP 2000-330359, filed in Japan on October 30, 2000, was claimed herein pursuant to 35 U.S.C. § 119.

In support of said claim, and to perfect same, filed herewith is a verified translation of the original foreign application.

Respectfully submitted,

February 8, 2007

Stephen W. Palan
Registration No. 43,420

CROWELL & MORING LLP
Intellectual Property Group
P.O. Box 14300
Washington, DC 20044-4300
Telephone No.: (202) 624-2500
Facsimile No.: (202) 628-8844
SWP:crr

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re patent application of
First Named Inventor: Kazuhiko HONDA
Serial No.: 11/210,902 Art Unit: 2655
Filed: August 25, 2005 Examiner:

For: Constant Angular Velocity Disk Label Printing

DECLARATION UNDER 37 CFR 1.55(a)
(Pursuant to 37 CFR 1.68)

Commissioner of Patents and Trademarks
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

I, TOSHIMASA SUZUKI, declare and state:

that I am a citizen of Japan, having an Office at P.O. Box 521, ARK Mori Building 13F, 12-32, Akasaka 1-chome, Minato-ku, Tokyo, 107 JAPAN;

that I well understand the Japanese and English languages;

that the attached English-language documents are full, true and faithful translations made by me of Japanese Application No. 2000-330359 filed on October 30, 2000 on which the rights of priority under the International Convention are all claimed for the

above-identified application.

I declare further that all statements made herein of my own knowledge are true that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful statements may jeopardize the validity of the Application or any patent issuing thereon.

Date: December 22, 2005

Toshimasa SUZUKI

PATENT OFFICE

Japanese Government

This is to certify that the annexed is a true copy of the following application as filed with this Office.

Date of Application: October 30, 2000

Application Number: Patent 2000-330359

Applicant(s): YAMAHA CORPORATION

October 1, 2001

Commissioner,
Patent Office: Kozo Oikawa (Seal)

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[Inventor]	
[Address or Residence]	c/o YAMAHA CORPORATION, 10-1, Nakazawa-cho, Hamamatsu-shi, Shizuoka-ken
[Name]	Kazuhiko HONDA
[Inventor]	
[Address or Residence]	c/o YAMAHA CORPORATION, 10-1, Nakazawa-cho, Hamamatsu-shi, Shizuoka-ken
[Name]	Tamon KONDO
[Applicant for Patent]	
[Identification No.]	000004075
[Name or Appellation]	YAMAHA CORPORATION
[Agent]	
[Identification No.]	100090228
[Attorney]	
[Name or Appellation]	Kunihiko Kato
[Telephone Number]	03(3359)9553
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[Designation of Document] SPECIFICATION

[Title of the Invention] METHOD OF PRINTING LABEL ON OPTICAL DISK, OPTICAL DISK UNIT, AND OPTICAL DISK

[Claims]

[Claim 1] A label surface printing method for an optical disk, the method comprising the steps of:

forming a visible-light-reflection-characteristic-changing layer in a position which can be viewed from a part of a label surface of an optical disk, the layer changing a characteristic of visible light entered from the part of the label surface upon exposure to a laser beam having a specific characteristic and emitted from the part of the label surface;

loading the optical disk on a turntable of an optical disk unit such that a label surface of the optical disk is oriented toward a direction in which a laser beam emitted from an optical pickup is to enter;

mutually moving the optical disk and the laser beam along a plane of the optical disk; and

modulating the laser beam, in synchronism with the mutual movement, into a specific characteristic in accordance with image data to be printed, such as characters or graphics, and radiating the modulated laser beam onto the visible-light-reflection-characteristic-changing layer from the part of the label surface, wherein a reflection

characteristic of the visible light having entered the visible-light-reflection-characteristic-changing layer is changed by means of exposure, thereby printing a corresponding image on the label surface.

[Claim 2] The label surface printing method for an optical disk according to claim 1, wherein the laser beam having specific characteristic is a laser beam of predetermined power or higher.

[Claim 3] The label surface printing method for an optical disk according to claim 1, wherein the optical pickup is moved in a radial direction of the optical disk while the optical disk is being rotated.

[Claim 4] The label surface printing method for an optical disk according to claim 1, wherein the optical disk is made stationary, and the optical pickup is moved in a radial direction of the optical disk as well as in a direction which is orthogonal to the radial direction of the optical disk and is tangent to a track.

[Claim 5] An optical disk unit comprising:

a relative movement mechanism for relatively moving an optical disk loaded on a turntable while a label surface is oriented in a direction in which a laser beam is to enter, and a laser beam emitted from an optical pickup along a plane of the optical disk;

a laser modulation circuit for modulating a laser beam emitted from the optical pickup to have specific characteristic;

and

a circuit for controlling the relative movement mechanism and the laser modulation circuit, wherein

the control circuit performs control operation of controlling the relative movement mechanism to mutually move the optical disk and the laser beam; and controlling the laser modulation circuit in accordance with image data, such as characters or graphic images, to be printed on a label surface of the optical disk, modulating a laser beam output from the optical pickup to have said specific characteristic on the basis of the image data, thereby printing the corresponding image on an area, which can be viewed from the part of a label surface of the optical disk, of visible-light-reflective-characteristic-changing layer, reflection characteristic of visible light changes by a laser beam having said specific characteristic.

[Claim 6] The optical disk unit according to claim 5, wherein the relative movement mechanism is equipped with a rotary drive device for rotationally driving a turntable and with a radial-direction feed drive device for moving the optical pickup in a radial direction of the optical disk; and wherein the control circuit controls the rotary drive device and the radial-direction feed drive device, thereby controlling relative movement between the optical disk and the laser beam.

[Claim 7] The optical disk unit according to claim 6,

wherein the control circuit drives the rotary drive device to a constant rotating speed, thereby driving the radial-direction feed drive device by a predetermined amount at each predetermined rotary position.

[Claim 8] The optical disk unit according to claim 6 or 7, further comprising:

a circumferential-direction position sensor for detecting a circumferential position on the optical disk, and a radial-direction position sensor for detecting a radial position of the optical pickup on the optical disk; and wherein the control circuit performs a control operation for modulating a laser beam emitted from the optical pickup to have the specific characteristic in accordance with the position detected by the circumferential-direction position sensor and that detected by the radial-direction position sensor and with image data to be printed on a label surface of the optical disk, such as characters or graphic images.

[Claim 9] The optical disk unit according to claim 8, wherein the circumferential-direction position sensor is equipped with a frequency generator which is rotated by the rotary drive device to generate a signal of frequency corresponding to rotation, and with a multiplier for multiplying the frequency of a signal generated by the frequency generator.

[Claim 10] The optical disk unit according to claim 5, wherein the relative movement mechanism is equipped with a

radial-direction feed drive device for moving the optical pickup in a radial direction of the optical disk, and with a track-tangential-direction feed drive device for moving the optical pickup in a direction which is orthogonal to the radial direction of movement and is tangent to a track of the optical disk; and wherein the control circuit controls relative movement between the optical disk and the laser beam by means of controlling the radial-direction position sensor and the track-tangential-direction feed drive device while the turntable is left in a stationary state.

[Claim 11] The optical disk unit according to claim 10, further comprising:

a circumferential-direction position sensor for detecting a circumferential position on the optical disk, and a track-tangential-direction position sensor for detecting a position which is orthogonal to the radial direction of movement and is tangent to a track of the optical disk; and wherein the laser beam emitted from the optical pickup is controlled to have said specific characteristic in accordance with the position detected by the circumferential-direction position sensor and that detected by the track-tangential-direction position sensor and with image data to be printed on a label surface of the optical disk, such as characters or graphic images.

[Claim 12] The optical disk unit according to any one

of claims 5 through 11, wherein the control circuit effects relative movement between the optical disk and the laser beam by means of turning off a tracking servo and turning on a focus servo.

[Claim 13] The optical disk unit according to any one of claims 5 through 12, wherein the control circuit performs a control operation for vibrating and driving a tracking actuator of the optical pickup while effecting relative movement between the optical disk and the laser beam.

[Claim 14] An optical disk comprising a visible-light-reflection-characteristic-changing layer which changes a visible characteristic by a laser beam having specific characteristic upon exposure to a laser beam having entered from a part of a label surface and which is integrally formed in a location capable of being viewed from the part of the label surface.

[Claim 15] The optical disk according to claim 14, wherein the visible-light-reflection-characteristic-changing layer is a color-changing layer which changes in color upon exposure to the laser beam having said specific characteristic.

[Claim 16] The optical disk according to claim 15, wherein the color-changing layer is a photosensitive or heat sensitive layer.

[Claim 17] The optical disk according to any one of claims 14 through 16, wherein the optical disk is constituted by means

of sequentially forming on, a substrate, at least a recording layer, a reflection layer, and a protective layer; and the visible-light-reflection-characteristic-changing layer is formed between the reflection layer and the protective layer.

[Claim 18] The optical disk according to claim 17, wherein an intermediate layer which improves adhesion of the reflection layer and the visible-light-reflection-characteristic-changing layer is disposed between the reflection layer and the visible-light-reflection-characteristic-changing layer; and the reflection layer and the intermediate layer are joined directly together, and the intermediate layer and the visible-light-reflection-characteristic-changing layer are joined directly together.

[Claim 19] The optical disk according to claim 17, wherein a part containing the visible-light-reflection-characteristic-changing layer and a part which does not include the visible-light-reflection-characteristic-changing layer and is joined directly to the reflection layer and to the protective layer are formed so as to be finely mixed between the reflection layer and the protective layer.

[Claim 20] The optical disk according to claim 19, wherein the visible-light-reflection-characteristic-changing layer is formed between the reflection layer and the protective layer

According to the method in which contents are written directly on the label surface of the disk, a recording layer is often damaged by a strong writing action effected by use of a stiff pencil. According to the method of printing a label with a printer, there is a necessity for using a printer.

The present invention has been conceived in light of the foregoing problem and aims at providing a label surface printing method for an optical disk, an optical disk unit, and an optical disk, wherein an image is formed on a label surface of an optical disk by utilization of a laser beam output from an optical disk unit, thereby obviating a necessity for writing of an image performed with a pen or printing an image with a printer.

[0004]

[Means for Solving the Problem]

The present invention provides a method of forming an image on a label surface of an optical disk, the method comprising the steps of: forming a visible-light-reflection-characteristic-changing layer in a position which can be viewed from a part of a label surface of an optical disk, the layer changing a reflection characteristic of visible light having entered from the part of the label surface upon exposure to a laser beam having specific characteristic and emitted from the part of the label surface; loading the optical disk on a turntable of an optical disk unit such that a label surface of the optical disk is oriented toward

a direction in which a laser beam emitted from an optical pickup is to enter; mutually moving the optical disk and the laser beam along a plane of the optical disk; and modulating the laser beam, in synchronism with the mutual movement, into a specific characteristic in accordance with image data to be printed, such as characters or graphic images, and radiating the modulated laser beam onto the visible-light-reflection-characteristic-changing layer from the part of the label surface, wherein a reflection characteristic of the visible light having entered the visible-light-reflection-characteristic-changing layer is changed by means of exposure, thereby printing a corresponding image on the label surface. According to the label surface printing method, a laser beam output from the optical disk unit can be radiated onto the visible-light-reflection-characteristic-changing layer formed in an area which can be viewed from the part of a label surface of an optical disk, thereby changing the reflection characteristic of the visible light. In this way, corresponding images, such as characters or graphic images, can be printed on the label surface, thereby obviating a necessity of writing images with a pen or printing images with a printer.

[0005]

Under the method according to the present invention, the laser beam having the specific characteristic can be a laser

beam of predetermined power or higher. The optical pickup can be moved in a radial direction of the optical disk while the optical disk is being rotated. The optical disk can be made stationary, and the optical pickup is moved in a radial direction of the optical disk as well as in a direction which is orthogonal to the radial direction of the optical disk and is tangent to a track.

[0006]

The present invention also provides an optical disk unit comprising: a relative movement mechanism for relatively moving an optical disk loaded on a turntable while a label surface is oriented in a direction in which a laser beam is to enter, and a laser beam emitted from an optical pickup along a plane of the optical disk; a laser modulation circuit for modulating a laser beam emitted from the optical pickup to have specific characteristic; and a control circuit for controlling the relative movement mechanism and the laser modulation circuit, wherein the control circuit performs control operation of controlling the relative movement mechanism to mutually move the optical disk and the laser beam; and controlling the laser modulation circuit in accordance with image data, such as characters or graphic images, to be printed on a label surface of the optical disk, modulating a laser beam output from the optical pickup to have the specific characteristic on the basis of the image data, and thereby forming the corresponding image

on an area, which can be viewed from the part of a label surface of the optical disk, of a visible-light-reflection-characteristic-changing layer, reflection characteristic of visible light changes by the exposure of the laser beam having the specific characteristic. The optical disk unit enables implementation of the label surface image formation method according to the present invention.

[0007]

Preferably, the relative movement mechanism is equipped with a rotary drive device for rotationally driving a turntable and with a radial-direction feed drive device for moving the optical pickup in a radial direction of the optical disk; wherein the control circuit can control the rotary drive device and the radial-direction feed drive device, thereby controlling relative movement between the optical disk and the laser beam. In this case, the control circuit can drive the rotary drive device to a constant rotating speed, thereby driving the radial-direction feed drive device by a predetermined amount at each predetermined rotary position. Further, the optical disk unit can further comprise a circumferential-direction position sensor for detecting a circumferential position on the optical disk, and a radial-direction position sensor for detecting a radial position of the optical pickup on the optical disk; wherein the control circuit can perform a control operation

for modulating a laser beam emitted from the optical pickup to have specific characteristic, in accordance with the position detected by the circumferential-direction position sensor and that detected by the radial-direction position sensor and with image data to be printed on a label surface of the optical disk, such as characters or graphic images. The positional information about image data can be expressed as coordinate data consisting of a combination of a circumferential position on an optical disk and a radial position on an optical disk. The circumferential-direction position sensor can be equipped with a frequency generator which is rotated by the rotary drive device to generate a signal of frequency corresponding to rotation, and with a multiplier for multiplying the frequency of a signal generated by the frequency generator. The relative movement mechanism can be equipped with a radial-direction feed drive device for moving the optical pickup in a radial direction of the optical disk, and with a track-tangential-direction feed drive device for moving the optical pickup in a direction which is orthogonal to the radial direction of movement and is tangent to a track of the optical disk; wherein the control circuit can control relative movement between the optical disk and the laser beam by means of controlling the radial-direction position sensor and the track-tangential-direction feed drive device while the turntable is left in a stationary state. The optical disk unit further comprises a circumferential-direction

position sensor for detecting a circumferential position on the optical disk, and a track-tangential-direction position sensor for detecting a position which is orthogonal to the radial direction of movement and is tangent to a track of the optical disk; wherein the laser beam emitted from the optical pickup can be controlled to have the specific characteristic in accordance with the position detected by the circumferential-direction position sensor and that detected by the track-tangential-direction position sensor and with image data to be printed on a label surface of the optical disk, such as characters or graphic images. The positional information about image data can be expressed as coordinate data consisting of a combination of a radial position on an optical disk and a position along a direction which is orthogonal to the radial direction of movement of the optical disk and is tangent to a track of the optical disk. Further, the control circuit effects relative movement between the optical disk and the laser beam by means of turning off a tracking servo and turning on/off a focus servo. The control circuit can perform a control operation for vibrating and driving a tracking actuator of the optical pickup while effecting relative movement between the optical disk and the laser beam. The optical disk unit according to the present invention can be embodied in, for example, an optical disk unit for a single-side CD-type optical disk, such as a CD-R (CD-R recordable) and CD-RW (CD rewritable).

[0008]

The present invention also provides an optical disk comprising a visible-light-reflection-characteristic-changing layer which changes a reflection characteristic by a laser beam having specific characteristic upon exposure to a laser beam having entered from a part of a label surface and which is integrally formed in a location capable of being viewed from the part of the label surface. The optical disk enables implementation of the label surface printing method according to the present invention. Since the visible-light-reflection-characteristic-changing layer is formed integrally on an optical disk, the method can prevent occurrence of vibration, which would otherwise be caused by mass eccentricity during high-speed rotation, and occurrence of failure, which would otherwise be caused by exfoliation of a label within a drive, as compared with a label depositing method.

[0009]

For example, the visible-light-reflection-characteristic-changing layer can be embodied in a color-changing layer which changes in color upon exposure to the laser beam. Further, the color-changing layer can be embodied in a photosensitive or heat sensitive layer. The optical disk can be constituted by means of

sequentially forming, on a substrate, at least a recording layer, a reflection layer, and a protective layer; and the visible-light-reflection-characteristic-changing layer can be formed between the reflection layer and the protective layer. An intermediate layer for improving adhesive between the reflection layer and the visible-light-reflection-characteristic-changing layer is disposed between the reflection layer and the visible-light-reflection-characteristic-changing layer, and the reflection layer and the intermediate layer can be joined directly together, and the intermediate layer and the visible-light-reflection-characteristic-changing layer can be joined directly together. The interface between the reflection layer and the protective layer can be formed so as to be a fine mixture of a part containing the visible-light-reflection-characteristic-changing layer and a part which does not include the visible-light-reflection-characteristic-changing layer and is joined directly to the reflection layer and to the protective layer. Since the optical disk has a part where the reflection layer and the protective layer are joined directly together, adhesion can be improved. Even when the visible-light-reflection-characteristic-changing layer is opaque, the reflection layer can be partially viewed from the part of the label surface via the part where no

visible-light-reflection-characteristic-changing layer is present and the reflection layer and the protective layer are joined together directly. Focus can be readily achieved on the reflection layer at the time of printing of an image on the label surface. The structure in which there are finely mixed together a part containing the visible-light-reflection-characteristic-changing layer and a part which does not include the visible-light-reflection-characteristic-changing layer and is joined directly to the reflection layer and to the protective layer can be embodied in a structure in which the visible-light-reflection-characteristic-changing layer is formed between the reflection layer and the protective layer in the form of a plurality of dots or a plurality of voids. The visible-light-reflection-characteristic-changing layer can be constituted in the form of concentric fringes or linear stripes, rather than in the form of dots or voids. The optical disk according to the present invention can be embodied in, for example, an optical disk unit for a single-side CD-type optical disk, such as a CD-R (CD-R recordable) or CD-RW (CD rewritable).

[0010]

[Modes for Implementing the Invention]

Embodiments of the present invention will be described hereinbelow. Fig. 1 shows an embodiment of an optical disk

according to the present invention in the form of a fragmentary cross section (the thickness of each layer differs from that of an actual layer, and a guide groove is omitted from the drawing). The embodiment shows an example in which the present invention is applied to a CD-R disk. An optical disk 10 is formed into a single piece, by means of sequentially forming, on a single side of a transparent substrate 12, a pigment layer (i.e., a recording layer) 14, a reflection layer 16, a visible-light-reflection-characteristic-changing layer 18, and a protective layer 20. The optical disk 10 is identical with an ordinary CD-R disk, except for provision of the visible-light-reflection-characteristic-changing layer 18. The visible-light-reflection-characteristic-changing layer 18 can be viewed by way of a transparent protective layer 20 from a label surface 22. Upon exposure to a laser beam of predetermined power or more emanated in the direction from a part of the label surface 22, the reflection characteristic (i.e., reflectivity, spectrum and the like) of the visible light having entered from the label surface are changed at the exposed area of the visible-light-reflection-characteristic-changing layer 18. The visible-light-reflection-characteristic-changing layer 18 can be formed from a material layer (i.e., a color changing layer, a photosensitive layer, or a heat sensitive layer) [which changes from, e.g., white to color (e.g., black) or from

transparent to color (e.g., black)] which changes in color, such as a photo-sensitive material or heat-sensitive material. When the visible-light-reflection-characteristic-changing layer 18 is formed from a photosensitive layer, there can be employed photosensitive material which is not photosensitized by a laser beam of 780 nm having entered from the part of the laser surface 22, the laser having power of less than 1 mW, but is photosensitized to thereby discolor upon exposure to a laser beam of 780 nm having power of 1 mW or more. When the visible-light-reflection-characteristic-changing layer 18 is formed from a heat-sensitive layer, there can be employed heat sensitive material which is not sensitive to a heat of less than 100°C but becomes sensitive to heat of 100°C or higher to thereby discolor. Since the laser beam enters the optical disk 10 from the part of the substrate 12 at the time of recording or playing back data from the optical disk 10 and is substantially cut off by the reflection layer 16, the visible-light-reflection-characteristic-changing layer 18 does not cause any change in the reflection characteristic.

[0011]

As shown in Fig. 2, if adhesion between the reflection layer 16 and the visible-light-reflection-characteristic-changing layer 18 is not good, an intermediate layer 24 can be provided therebetween. As the intermediate layer 24, material having good adhesive

both for the reflection layer 16 and the visible-light-reflection-characteristic-changing layer 28 is employed. As shown in Fig. 3, in lieu of the intermediate layer 24, the visible-light-reflection-characteristic-changing layer 18 is formed into a structure having a plurality of minute dots (e.g., each assuming a circular shape having a diameter of tens of micrometers or a non-circular shape of similar size), through use of, e.g., a film transfer technique. Alternatively, in place of a plurality of minute pores, the visible-light-reflection-characteristic-changing layer 18 can be formed into a porous structure having a plurality of minute pores 26. In a case where the visible-light-reflection-characteristic-changing layer 18 is formed into the structure having dots such as that shown in Fig. 3, the reflection layer 16 and the protective layer 20 are joined together directly outside the dots. In a case where the visible-light-reflection-characteristic-changing layer 18 is formed into the structure having pores such as that shown in Fig. 4, the reflection layer 16 and the protective layer 20 are directly joined together within the pores. As a result, there can be achieved good adhesion. Even when the visible-light-reflection-characteristic-changing layer 18 is opaque, the reflection layer 16 can be partially viewed from the part of the label surface 22, by way of an area where no visible-light-reflection-characteristic-changing layer 18 is

present and at which the reflection layer 16 and the protective layer 20 are joined together directly. At the time of printing of the label surface 22, focusing on the reflection layer 16 can be achieved readily. The visible-light-reflection-characteristic-changing layer 18 can be made into a structure having concentric fringes or linear stripes.

[0012]

Fig. 5 shows another embodiment of the optical disk according to the present invention in the form of a fragmentary cross section (the thickness of each layer differs from that of an actual layer, and a guide groove is omitted from the drawing). The fragmentary cross section illustrates an example in which the present invention has been applied to a CD-RW disk. An optical disk 28 is formed into a single piece, by means of sequentially forming, on a single side of a transparent substrate 30 of, for example, polycarbonate, a dielectric layer 32, a recording layer 34, a dielectric layer 36, a reflection layer 38, a visible-light-reflection-characteristic-changing layer 40, and a protective layer 42. The optical disk 28 is identical with an ordinary CD-R disk, except for provision of the visible-light-reflection-characteristic-changing layer 40. The visible-light-reflection-characteristic-changing layer 40 can be viewed from the part of a label surface 44, by way of a transparent protective layer 42. The

visible-light-reflection-characteristic-changing layer 40 can be constituted in the same manner as the visible-light-reflection-characteristic-changing layer 18 described in connection with the optical disk shown in Fig. 1. As in the case of the optical disk 10 shown in Fig. 2, an intermediate layer for improving adhesive can be interposed between the reflection layer 38 and the protective layer 42. Further, the visible-light-reflection-characteristic-changing layer 40 can be formed into a structure having a plurality of minute spots, as in the case of the visible-light-reflection-characteristic-changing layer 18 shown in Fig. 3. Alternatively, the visible-light-reflection-characteristic-changing layer 40 can be formed into a porous structure having a plurality of minute pores, as shown in Fig. 4. As another alternative, the visible-light-reflection-characteristic-changing layer 40 can be formed into a structure having concentric fringes or a structure having linear stripes.

[0013]

Fig. 6 shows an embodiment of the optical disk unit according to the present invention (showing only the portions of the unit pertaining to printing of a label surface). The optical disk unit is configured as a CD-R/RW drive (an optical disk drive which enables recording and reproduction of data

on and from a CD-R disk and a CD-RW disk) used for connection with a host computer 46, such as a personal computer. An optical disk 50 according to the present invention (or the CD-R disk shown in Figs. 1 through 4 or the CD-RW disk 28 shown in Fig. 5) is placed on a turn-table 54 while being inverted (i.e., while a label surface 52 is turned down). The optical disk 50 is rotated and driven. A frequency generator (FG) 58 is coupled directly to a rotary shaft of a spindle motor 56. The frequency generator 58 produces a pulse signal (FG pulse) for each turning angle, the angle being determined by means of dividing one rotation of the spindle motor 56 by a predetermined integer. The FG pulse signal is multiplied by a predetermined number by means of a multiplier 60 consisting of a PLL circuit. The thus-multiplied FG pulse is input to a system control circuit (CPU) 62, where the signal is used for detecting a peripheral position. At the time of printing of a label surface, a spindle servo circuit 64 controls, on the basis of the FG pulse signal, the spindle motor 56 so as to rotate constantly at a rotating speed instructed by the system control circuit 62.

[0014]

An optical pickup 66 is provided at a position lower than the optical disk 50 for effecting recording and reproduction of data and printing of a label. By means of a feed screw 68, the optical pickup 66 is supported so as to be able to move in the radial direction of the optical disk 50. In accordance

with an instruction output from the system control circuit 62, a feed motor 72 is driven by way of a motor driver 70, thereby rotating the feed screw 68. As a result, the optical pickup 66 is moved in the radial direction of the optical disk 50. A feed position sensor 74, such as a linear scale, detects the radial position of the optical pickup 66 on the optical disk 50. In accordance with an instruction output from the system control circuit 62, a focus servo circuit 76 actuates a focus actuator of the optical pickup 66 on the basis of a focus error signal, thus effecting focus control operation. At the time of printing of a label surface, the focus servo circuit 76 is turned on. At the time of recording or reproduction of data, a tracking servo circuit 78 actuates a tracking actuator of the optical pickup 66 on the basis of a tracking error signal in accordance with the instruction output from the system control circuit 62, thus effecting tracking control operation. At the time of printing of a label surface, the tracking servo circuit 78 is turned off. At the time of printing of a label surface, a vibration signal generation circuit 80 produces a predetermined vibration signal in accordance with the instruction output from the system control circuit 62, and supplies the vibration signal to the tracking actuator. By means of the signal, an object lens of the optical pickup 66 is vibrated in the radial direction of the optical disk 50 to thereby bridge a gap between the areas circularly scanned by

a laser beam, as a result of which there is obtained a print product having no gaps.

[0015]

In accordance with the instruction output from the system control circuit 62, the laser driver 82 drives a laser diode of the optical pickup 66 to radiate a laser beam onto the optical disk 50, thereby effecting recording/reproduction of data or printing of a label surface. At the time of recording of data, the laser diode outputs a laser beam of recording power modulated by a recording signal. At the time of reproduction of data, the laser diode outputs a laser beam of given reproduction power. At the time of printing of a label surface, the laser diode outputs a laser beam modulated with image data pertaining to characters or graphic images to be printed (i.e., a laser beam which attains high power so as to cause changes in the visible-light-reflection-characteristic-changing layer in an area to be printed and which attains low power so as not to cause changes in the visible-light-reflection-characteristic-changing layer in an area not to be printed). At the time of printing of a label surface, the host computer 46 delivers, to a CD-R/RW drive 48, image data pertaining to characters or graphic images to be edited and printed by a user. The image data are composed of data (e.g., data which specify a print segment represented by an angle θ for each radial position "r" at a predetermined pitch

Δr) represented by coordinates (r, θ), the coordinates corresponding to a combination of a radial position "r" of an optical disk (a distance from a rotation center) and a circumferential position θ (a circumferential angle relative to an appropriate reference position).

[0016]

Processing pertaining to processes of printing data on a label surface of the optical disk 50 by means of the CD-R/RW drive 48 shown in Fig. 6 is performed in the manner described below.

(1) The optical disk 50 is loaded on the turntable 54 while being inverted switchably between during recording of data and reproduction of data.

(2) A user edits, on a display of the host computer 46, characters to be printed or a graphic image such as a picture. The host computer 46 converts the thus-edited image into image data.

(3) The user instructs initiation of printing operation on the host computer 46.

(4) The spindle servo circuit 64 subjects the spindle motor 56 to CAV (constant rotating speed) control such that the pulse produced by the frequency generator 58 assumes a given frequency instructed by the system control circuit 62.

(5) The optical pickup 66 is positioned at a predetermined radial reference position at the inner radius of the optical

disk 50.

(6) The laser driver 82 drives the laser diode such that the laser power of a laser diode of the optical pickup 66 assumes a predetermined low output instructed by the system control circuit 62 (a value which enables focus control operation without involvement of occurrence of changes in the visible-light-reflection-characteristic-changing layer: e.g., a value of 1 mW or less).

(7) In accordance with the instruction output from the system control circuit 62, the focus servo circuit 76 is turned on. As a result, the focus servo circuit 76 effects focus servo operation such that the laser beam 67 forms the minimum spot on the reflection layer. Here, the tracking servo circuit 78 remains off, and no tracking servo operation is effected.

(8) Through the foregoing operations, preparation for printing is made, and printing is commenced in accordance with the instruction output from the system control circuit 62. More specifically, the system control circuit 62 receives image data from the host computer 46, thereby driving the feed motor 72 to position the optical pickup 66 in a radial position at the inner radius of the optical disk 50, where a first print location is present. While appropriate timing based on the FG pulse signal (or a detection timing for a sensor additionally provided for detecting a reference circumferential position) is taken as a circumferential reference position, a pulse signal output

from the multiplier 60 is counted, thereby detecting a circumferential position θ. In connection with the radial position on the disk, laser power is switched to a predetermined high output (a value at which changes arise in the visible-light-reflection-characteristic-changing layer; for example, a value of 1 mW or more) in each circumferential print position instructed on the basis of image data. As a result, changes (i.e., discoloration) arise in the reflection characteristic changing layer at the location exposed to the laser beam of high output power, thereby effecting printing operation. When the optical disk 50 returns to the circumferential reference position after having effected one rotation, the feed motor 62 is actuated, thereby moving the optical pickup 66 toward an outer circumference at a predetermined pitch Δr, and the printing is performed by switching the laser power to a predetermined high output at each printing position in a circumference direction instructed by the image data as to the radius position. Therefore, this operated repeats and the printing is performed by moving a position sequentially in outer direction by a predetermined pitch Δr for each rotation. Fig. 7 shows the locus of movement of the laser beam over the label surface 52 of the optical disk 50 through the printing operation. In the area designated with thick lines, the laser power of the laser beam is switched to high power, thereby effecting printing operation. Fig. 8 shows

variations in the laser power of the laser beam when the printing operation shown in Fig. 7 is performed.

[0017]

Scanning is not performed at radial positions where there is no print area, and, by a single operation, the optical pickup 66 moves to a radial position where the next print area is present, and printing is effected. If the pitch Δr is large, an image which is originally to be printed without interruption in the radial direction is printed with involvement of gaps, as shown in Fig. 9. In contrast, if the pitch Δr is made small, gaps can be made unnoticeable. However, the number of rotations required for printing data on the entire label surface is increased, and printing involves consumption of time. For this reason, the CD-R/RW drive 48 drives a tracking actuator with a vibration signal (e.g., a sinusoidal signal or triangular signal) originating from the vibration signal generation circuit 80 during a printing operation, thereby vibrating the objective lens in the radial direction of the optical disk 50. As shown in Fig. 10, the laser beam is vibrated in the radial direction of the optical disk 50, thereby enabling a printing operation without involvement of gaps (or with occurrence of small gaps) even at a comparatively large pitch Δr. The frequency of the vibration signal can be set to, e.g., several kilohertz or thereabouts. Further, the pitch Δr can be set to, e.g., 50 to 100 μm or thereabouts.

[0018]

Fig. 11A shows a practical example of a print made on the label surface 52 by the CD-R/RW drive 48. Fig. 11B shows a fragmentary enlarged view showing the locus of movement of a laser beam used during printing of the print example. The drawing shows that, when scanning in a radial position r1 is performed, the laser power of the laser beam is increased within an angular segment from θ1 to θ2. Figs. 12A through 12C show other examples of print products made on the label surface 52 by means of the CD-R/RW drive 48. Arbitrary character information, such as disk titles, music titles, the names of artists, or pictures can be printed.

[0019]

Fig. 13 shows another embodiment of the optical disk unit according to the present invention (showing only the elements contributing to printing of a label surface). In a CD-R/RW drive 84, the optical disk 50 (the CD-R disk 10 shown in Fig. 10 or the CD-RW disk 28 shown in Fig. 5) according to the present invention is loaded on a turntable 86 while being inverted (i.e., while the label surface 52 is turned down). At the time of printing operation, the spindle motor 88 is not driven. An optical pickup 90 for effecting recording or reproduction of data is provided at a location lower than the optical disk 50. The optical pickup 90 is supported by a feed screw 92 so as to be movable in the radial direction of the optical disk 50.

In accordance with the instruction output from the system control circuit 62, a feed motor 94 is driven by way of a motor driver 96, thereby rotating the feed screw 92. The optical pickup 90 is then moved in the radial direction of the optical disk 50. The radial direction of the optical pickup 90 on the optical disk 50 is detected by a feed position sensor 98 such as a linear scale.

[0020]

The entirety of the disk radial feed mechanism having the feed screw 92 and the feed motor 94 is movably supported by a feed screw 101 disposed in parallel with the plane of the disk 50 perpendicular to the feed screw 92, so as to be movable in the direction tangent to a track (i.e., a direction perpendicular to a feed direction in the radial direction of the disk). In accordance with an instruction output from a system control circuit 105, a feed motor 103 is driven by way of a motor driver 107, thereby rotating the feed screw 101. As a result, the optical pickup 90 is moved in the direction tangent to a track. The position of the optical pickup 90 in the direction tangent to a track is detected by a feed position sensor 109 such as a linear scale.

[0021]

Fig. 14 shows an example of layout of a feed mechanism (neither a feed motor nor a feed screw is shown). Slide bars 111 are fixedly provided in a mechanical base of the CD-R/RW

drive 84 in parallel with the plane of the optical disk 50. An optical pickup unit 113 is slidably supported on the slide bar 111. The optical pickup unit 113 is moved along the slide bars 111 by means of the feed motor 103 and the feed screw 101 (shown in Fig. 13). Slide bars 115 are fixedly mounted on the optical pickup unit 113 in parallel with the plane of the optical disk 50 and orthogonal to the slide bars 111. The optical pickup 90 is slidably supported on the slide bars 115 and is moved along the slide bars 115 by means of the feed motor 94 and the feed screw 92 (shown in Fig. 13). At the time of printing operation, feed mechanisms for effecting feed in two directions are activated. At the time of recording/reproduction of data, only the mechanism for effecting feeding operation in the radial direction of a track is driven. The mechanism for effecting feeding operation in the direction tangent to a track is stopped in a neutral position thereof (i.e., the position in which an objective lens 90a of the optical pickup 90 is moved in the radial direction of a disk by means of driving of the track-radial-direction feed mechanism).

[0022]

Alternatively, the track-tangential-direction feed mechanism can move the spindle motor 88 instead of moving the optical pickup 90. In this case, a feed screw 117 and a feed motor 119 for moving the spindle motor 88 in the same direction are provided in lieu of the feed screw 101 and the feed motor

103 for moving the optical pickup 90 in the direction tangent to a track. Fig. 15 shows an example layout of the feed mechanism in such a case (neither the feed motor 119 nor the feed screw 117 is shown). Slide bars 121 are fixedly provided in a mechanical base of the CD-R/RW drive 84 in parallel with the plane of the optical disk 50. A spindle motor 88 is slidably supported on the slide bars 121. The spindle motor 88 is moved along the slide bars 121 by means of a feed motor 119 and a feed screw 117 (see Fig. 13). Slide bars 123 are fixedly mounted in a mechanical base of the CD-R/RW drive 84. The optical pickup 90 is slidably supported on the slide bars 123 and is moved along the slide bars 123 by means of the feed motor 94 and the feed screw 92 (shown in Fig. 13). At the time of printing operation, feed mechanisms for effecting feeding in two directions are activated. At the time of recording/reproduction of data, only the track-radial-direction feed mechanism is activated. The track-tangential-direction feed mechanism is stopped in a neutral position thereof (i.e., the position in which an objective lens 90a of the optical pickup 90 is moved in the radial direction of a disk by means of driving of the track-radial-direction feed mechanism).

[0023]

Referring to Fig. 13, in accordance with an instruction output from the system control circuit 105, a focus servo circuit

125 actuates a focus actuator of the optical pickup 90 on the basis of a focus error signal, thus effecting focus control operation. At the time of printing of a label surface, the focus servo circuit 125 is turned on. At the time of recording or reproduction of data, a tracking servo circuit 127 actuates a tracking actuator of the optical pickup 90 on the basis of a tracking error signal in accordance with the instruction output from the system control circuit 105, thus effecting tracking control operation. At the time of printing of a label surface, the tracking servo circuit 127 is turned off. At the time of printing of a label surface, the vibration signal generation circuit 129 produces a predetermined vibration signal in accordance with the instruction output from the system control circuit 105, and supplies the vibration signal to the tracking actuator. By means of the signal, an object lens of the optical pickup 90 is vibrated in the radial direction of the optical disk to thereby bridge a gap between the areas circularly scanned by a laser beam, as a result of which there is obtained a print product having no gaps.

[0024]

In accordance with the instruction output from the system control circuit 105, a laser driver 131 drives a laser diode of the optical pickup 66 to radiate a laser beam onto the optical disk 50, thereby effecting recording/reproduction of data or printing of a label surface. At the time of recording of data,

the laser diode outputs a laser beam of recording power modulated by a recording signal, by means of driving action of the laser driver 131. At the time of reproduction of data, the laser diode outputs a laser beam whose recording power has been modulated by a recording signal. At the time of printing of a label surface, the laser diode outputs a laser beam modulated with image data pertaining to characters or graphic images to be printed (i.e., a laser beam which attains high power to cause changes in the visible-light-reflection-characteristic-changing layer in an area to be printed and which attains low power so as not to cause changes in the visible-light-reflection-characteristic-changing layer in an area not to be printed). At the time of printing of a label surface, a host computer 133 delivers, to the CD-R/RW drive 84, image data pertaining to characters or graphic images to be edited and printed by the user. The image data are composed of dot-matrix data (e.g., data which specify a print segment in the direction tangent to a track represented by "t," for each radial position "r" at a predetermined pitch Δr) represented by coordinates (r, t), the coordinates corresponding to a combination of a radial position "r" of an optical disk [a distance from an appropriate reference position (e.g., rotation center) in the radial direction of the disk] and a position "t" in the direction tangent to a track (a distance from the

appropriate reference position in the direction tangent to a track).

[0025]

Processing pertaining to processes of printing data on a label surface of the optical disk 50 by means of the CD-R/RW drive 84 shown in Fig. 13 is performed in the manner described below.

(1) The optical disk 50 is loaded on the turntable 86 while being inverted switchably between during recording of data and reproduction of data.

(2) A user edits, on a display of the host computer 133, characters to be printed or a graphic image such as a picture. The host computer 133 converts the thus-edited image into image data.

(3) The user instructs initiation of printing operation on the host computer 133.

(4) During the course of printing operation, the spindle motor 88 is stopped in accordance with the instruction output from the system control circuit 105.

(5) The optical pickup 90 is positioned in a predetermined reference position.

(6) The laser driver 131 drives the laser diode such that laser power of the laser diode of the optical pickup 90 becomes a predetermined low output instructed by the system control circuit 105 (i.e., a value at which no changes arise in the

visible-light-reflection-characteristic-changing layer and focus control operation can be effected; for example, a value of 1 mW or less).

(7) In accordance with the instruction output from the system control circuit 105, the focus servo circuit 125 is turned on. As a result, the focus servo circuit 125 effects focus servo operation such that the laser beam forms the minimum spot on the reflection layer. Here, the tracking servo circuit 127 remains off, and no tracking servo operation is effected.

(8) Through the foregoing operations, preparation for printing is made, and printing is commenced in accordance with the instruction output from the system control circuit 105. More specifically, the system control circuit 105 receives image data from the host computer 133, thereby driving the feed motor 94 to position the optical pickup 90 in a radial position at the inner radius of the optical disk 50, where a first print location is present. The motor 103 (or 119) is driven at the radial position, thereby moving a laser beam to the direction tangent to a track. In connection with the radial position on the disk, laser power is switched to a predetermined high output (a value at which changes arise in the visible-light-reflection-characteristic-changing layer: for example, a value of 1 mW or more) over a print segment in the direction tangent to a track instructed on the basis of image data. As a result, changes (i.e., discoloration) arise in the

reflection characteristic changing layer at the location exposed to the laser beam of high output power, thereby effecting printing operation. The feed motor 94 is actuated to move the optical pickup 90 toward an outer circumference at a predetermined pitch Δr. The laser power is switched to a predetermined high output level over the print segment in the direction tangent to a track instructed on the basis of the image data with regard to the radial position on the disk while the optical pickup 90 is moved in that position in the direction tangent to a track, thereby effecting printing operation. In subsequent processes, these operations are iterated, thereby sequentially moving the optical pickup 90 toward the outer circumference at the predetermined pitch Δr. Fig. 16 shows the locus of movement of the laser beam over the label surface 52 of the optical disk 50 through the printing operation and a resultant print product. The laser beam is moved while being vibrated by means of the vibration signal, there is produced a print product having no gaps (or having small gaps).

[0026]

In the present embodiment, the visible-light-reflection-characteristic-changing layer is interposed between a reflection layer and a protective layer. However, the optical disk according to the present invention is not limited to such a structure. The visible-light-reflection-characteristic-changing layer can

be provided in any area (e.g., on a protective layer) viewed from a part of a label surface of an optical disk. Although the embodiment has described a case where the optical disk according to the present invention having a visible-light-reflection-characteristic-changing layer formed integrally is subjected to printing, printing required by the label surface printing method and optical disk unit according to the present invention is not limited to such printing. More specifically, an optical disk to which a label having a visible-light-reflection-characteristic-changing layer is affixed can be subjected to printing by application of the label surface printing method and optical disk unit according to the present invention. In the embodiment, a label surface is subjected to printing while focus servo operation is being performed. However, when no request exists for a print resolution, printing can be performed without involvement of focus servo operation. In that case, reflected light required for effecting focus servo operation is not necessary. Hence, the visible-light-reflection-characteristic-changing layer can be formed into an opaque form so as not to be able to see reflection layer through the visible-light-reflection-characteristic-changing layer. In the embodiment, printing is effected by means of modulating power of the laser beam in accordance with image data. However, if there are parameters other than power which enable occurrence

of changes in the visible-light-reflection-characteristic-changing layer by means of modulating power in accordance with image data, printing can be effected by means of modulating the parameters. The embodiment has described a case where changes arising in the visible-light-reflection-characteristic-changing layer correspond to discoloration. However, the present invention is not limited to this embodiment. Any type of change may be employed, so long as the change is visually recognizable. In the embodiment, an optical disk is sequentially subjected to printing from its internal circumference to outer circumference. However, the present invention is not limited to such a sequence. An optical disk may be sequentially subjected to printing from its outer to inner circumference or in another appropriate sequence. The embodiment has described a case where a CD-R disk or CD-RW disk is subjected to printing. However, the present invention can also be applied to a case where another type of optical disk is subjected to printing. Moreover, the embodiment has described a case where the present invention has been applied to the optical disk unit which is used while being connected to a host computer. However, the present invention can be also applied to an optical disk unit which is used in a standalone manner, such as a CD recorder.

[Brief Description of the Drawings]

Fig. 1 is a fragmentary cross section showing an embodiment

of an optical disk according to the present invention;

Fig. 2 is a fragmentary cross section showing a modification of the optical disk shown in Fig. 1;

Fig. 3 is a fragmentary cross section showing another modification of the optical disk shown in Fig. 1;

Fig. 4 is a fragmentary cross section showing yet another modification of the optical disk shown in Fig. 1;

Fig. 5 is fragmentary cross section showing another embodiment of the optical disk according to the present invention;

Fig. 6 is a system configuration block diagram showing an embodiment of an optical disk unit according to the present invention;

Fig. 7 is a plan view showing the locus of movement of a laser beam on a label surface stemming from an operation for subjecting the label surface to printing through use of a CD-R/RW drive shown in Fig. 6;

Fig. 8 is a timing chart showing changes in laser power which arise during the course of the printing operation shown in Fig. 7;

Fig. 9 is a plan view showing the locus of movement of a laser beam over a label surface arising when printing is effected without vibrating the laser beam in a radial direction of the optical disk;

Fig. 10 is a plan view showing the locus of movement of

a laser beam over a label surface arising when printing is effected while vibrating the laser beam in a radial direction of the optical disk;

Fig. 11 is a plan view showing an example of a print made on the label surface by means of the CD-R/RW drive shown in Fig. 6;

Fig. 12 is a plan view showing another example of a print made on the label surface by means of the CD-R/RW drive shown in Fig. 6;

Fig. 13 is a system configuration block diagram showing another embodiment of the optical disk unit according to the present invention;

Fig. 14 is a plan and front view showing an example layout of the CD-R/RW drive feed mechanism shown in Fig. 13;

Fig. 15 is a plan and front view showing the example layout of the CD-R/RW drive feed mechanism shown in Fig. 13; and

Fig. 16 is a plan view showing an example of a print product formed on the label surface by means of the CD-R/RW drive shown in Fig. 13.

[Description of the Reference Numerals]

10, 28, 50 … OPTICAL DISK; 14, 34 … RECORDING LAYER; 16, 38 … REFLECTION LAYER; 18, 40 … VISIBLE-LIGHT-REFLECTION-CHARACTERISTIC-CHANGING LAYER; 20, 42 … PROTECTIVE LAYER; 22, 44, 52 … LABEL SURFACE; 24 … INTERMEDIATE LAYER; 26 … HOLE; 48, 84 … CD-R/RW DRIVE (OPTICAL

DISK UNIT); 54, 86 ... TURN TABLE; 56 ... SPINDLE MOTOR (ROTARY DRIVE DEVICE); 58 ... FREQUENCY GENERATOR (CIRCUMFERENTIAL-DIRECTION POSITION SENSOR); 60 ... MULTIPLIER; 61, 105 ... SYSTEM CONTROL CIRCUIT (CIRCUMFERENTIAL-DIRECTION POSITION SENSOR); 66, 90 ... OPTICAL PICKUP; 67, 91 ... LASER BEAM; 68, 72, 92, 94, 101, 103, 111, 11, 115, 117, 119, 121, 123 ... RELATIVE MOVEMENT MECHANISM; 72, 94 ... FEED MOTOR (RADIAL-DIRECTION FEED DRIVE DEVICE); 74, 98 ... FEED POSITION SENSOR (RADIAL-DIRECTION POSITION SENSOR); 76, 125 ... FOCUS SERVO CIRCUIT; 78, 127 ... TRACKING SERVO CIRCUIT; 80, 129 ... VIBRATION SIGNAL GENERATION CIRCUIT; 82, 131 ... LASER DRIVER (LASER MODULATION CIRCUIT); 103, 119 ... FEED MOTOR (TRACK-TANGENTIAL-DIRECTION FEED DRIVE UNIT); 109 ... FEED POSITION SENSOR (TRACK-TANGENTIAL-DIRECTION POSITION SENSOR)

[Designation of Document] Abstract of the Disclosure

[Abstract]

[Problem] To subject a label surface of an optical disk to printing by means of utilization of a laser beam emitted from an optical disk unit.

[Means for Resolution] A visible-light-reflection-characteristic-changing layer formed from photosensitive or heat-sensitive material is formed in a location which can be viewed from a part of a label surface of an optical disk. The optical disk is loaded on a turntable of an optical disk unit while the label surface of the optical disk is directed downward. The optical disk and an optical pickup are moved mutually along the plane of the optical disk. In synchronism with the relative movement, the power of a laser beam output from the optical pickup is modulated in accordance with image data, such as characters or graphic images to be printed, and the laser beam is radiated onto the visible-light-reflection-characteristic-changing layer. As a result of the visible-light-reflection-characteristic-changing layer being exposed to the laser beam, a visible-light reflectivity of the visible-light-reflection-characteristic-changing layer is changed, thereby forming a corresponding image on the label surface.

[Selected Drawing] Fig. 1

FIG. 1

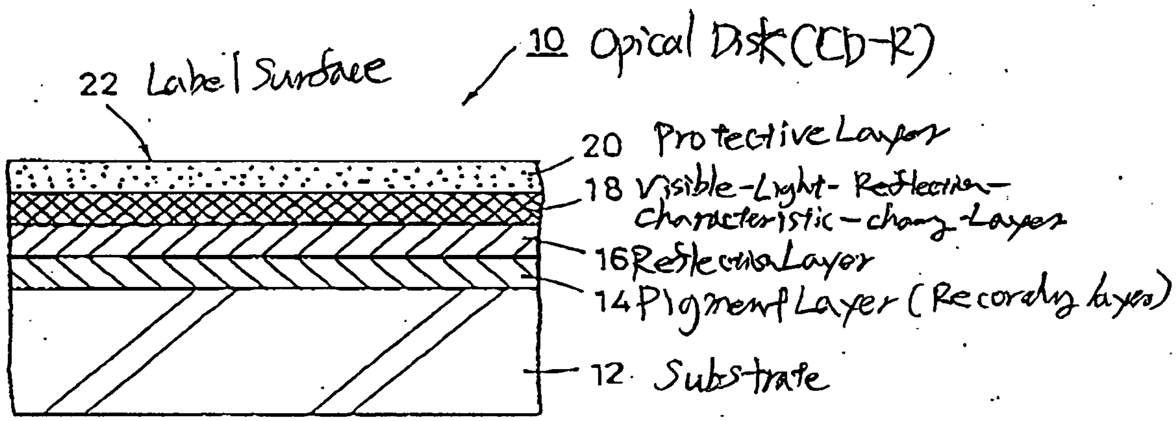

10 Opical Disk (CD-R)
22 Label Surface
20 Protective Layer
18 Visible-Light-Reflection-Characteristic-change-Layer
16 Reflection Layer
14 Pigment Layer (Recording layer)
12 Substrate

FIG. 2

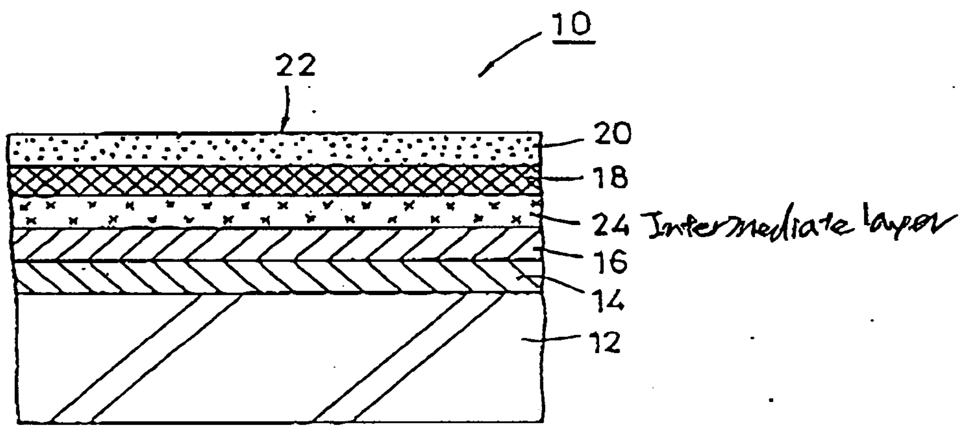

10
22
20
18
24 Intermediate layer
16
14
12

FIG.3

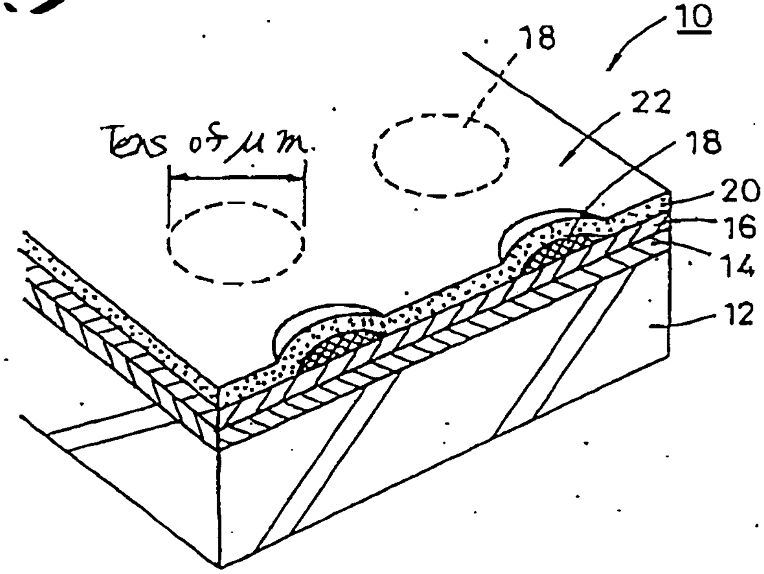
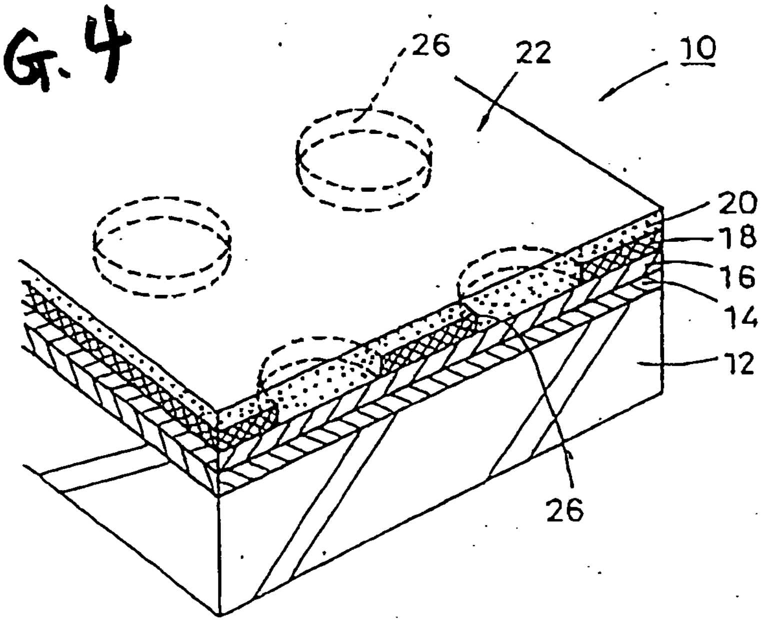


FIG.4



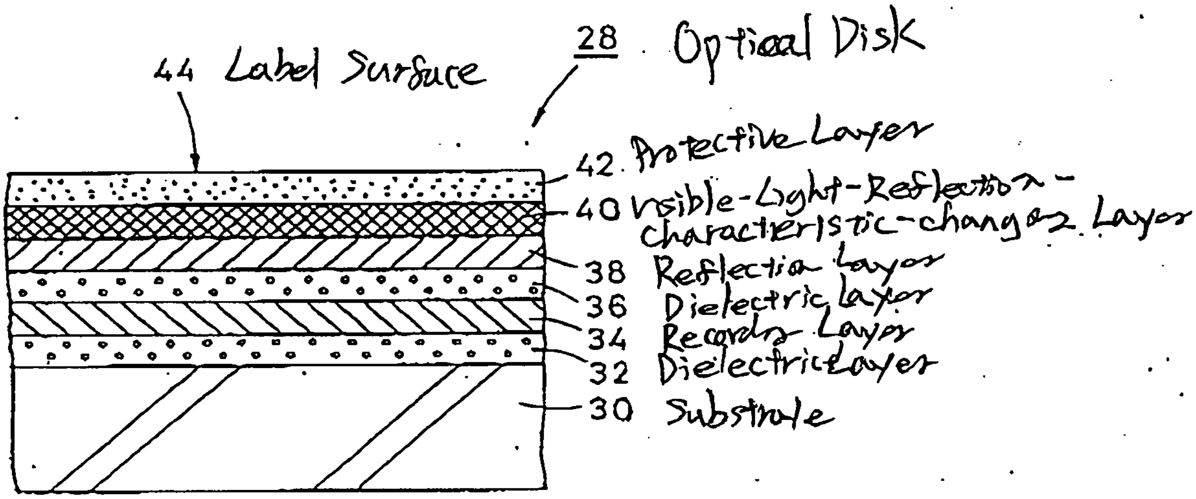

44 Label Surface
28 Optical Disk
42 Protective Layer
40 Visible-Light-Reflection-Characteristic-Change Layer
38 Reflection Layer
36 Dielectric Layer
34 Recording Layer
32 Dielectric Layer
30 Substrate

FIG 5

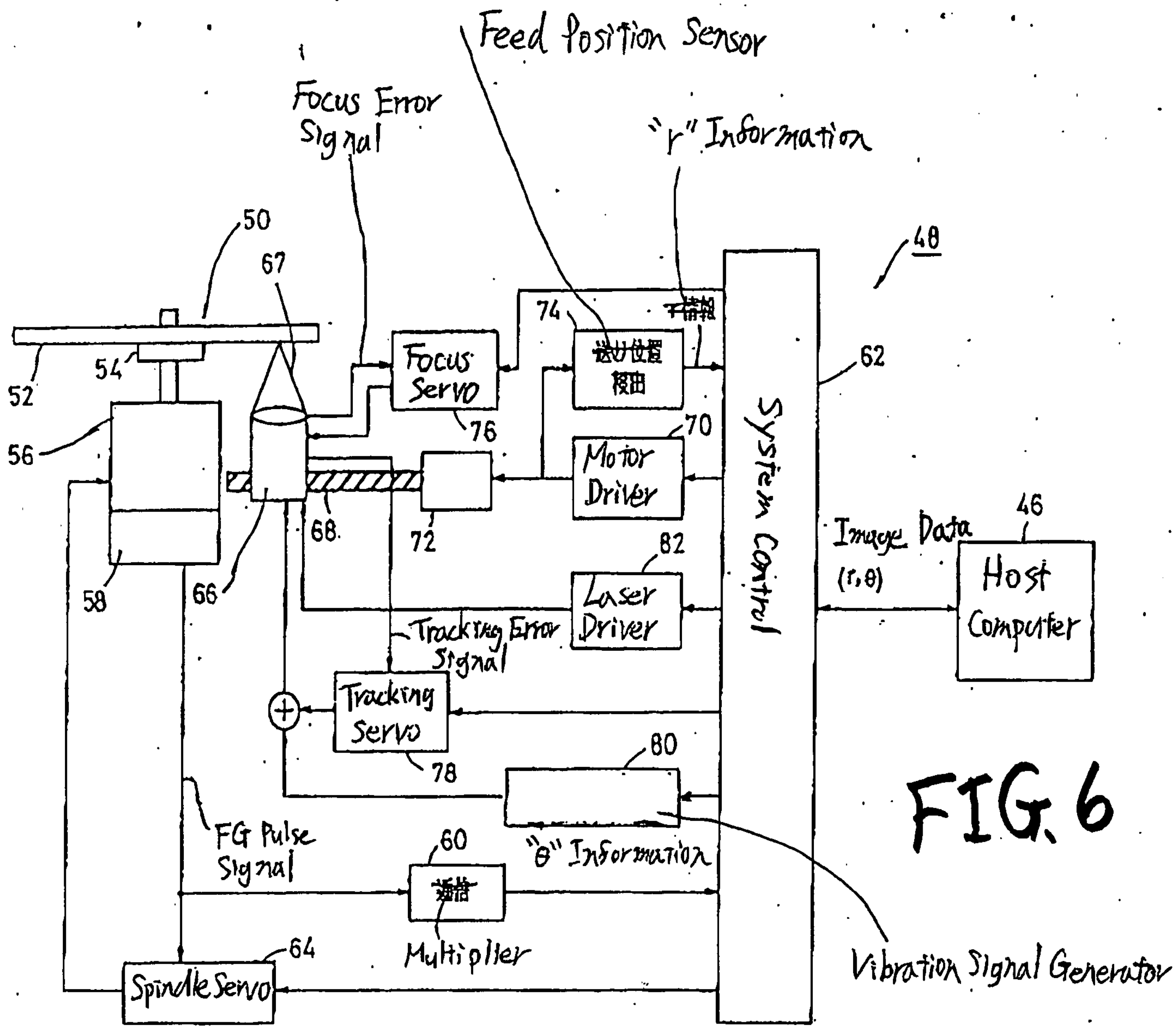


FIG. 6

56: Spindle Motor
58: Frequency Generator
66: Optical Pickup

68: Feed Screw
72: Feed Motor

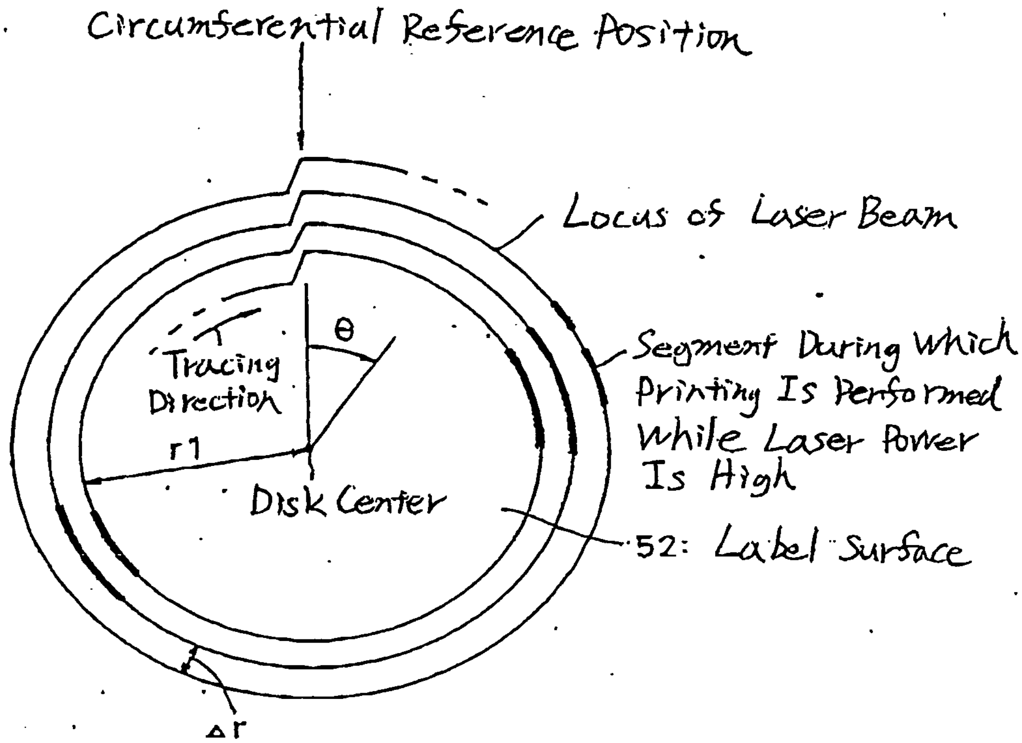

Circumferential Reference Position
Locus of Laser Beam
Segment During Which Printing Is Performed While Laser Power Is High
θ
Tracing Direction
r1
Disk Center
52: Label Surface
Δr

FIG. 7

FIG. 8

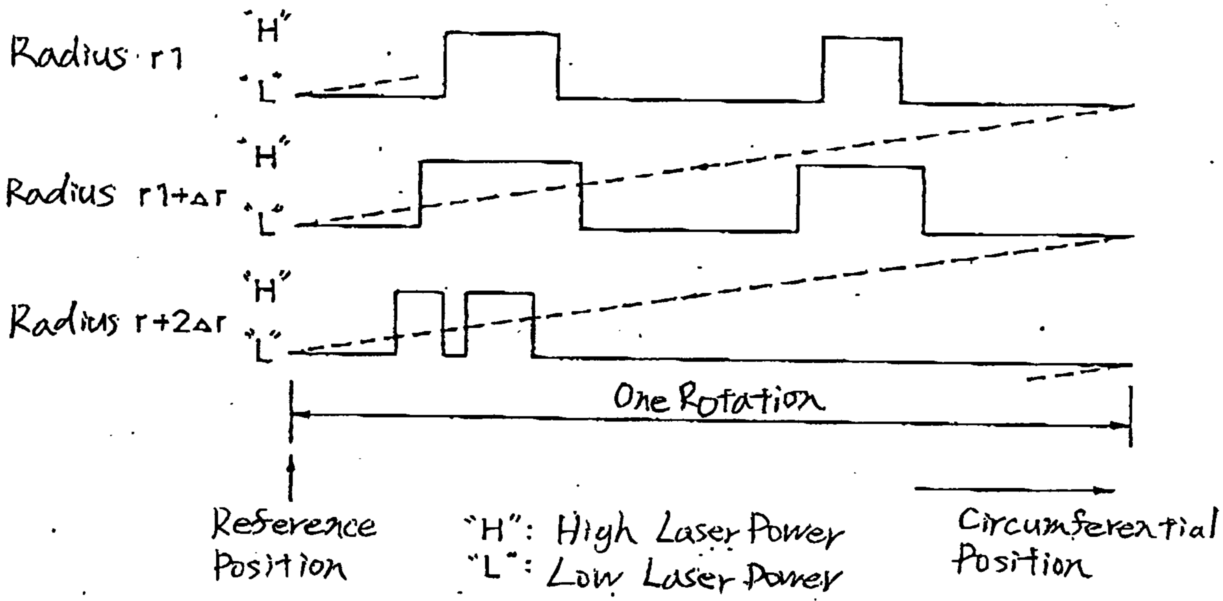
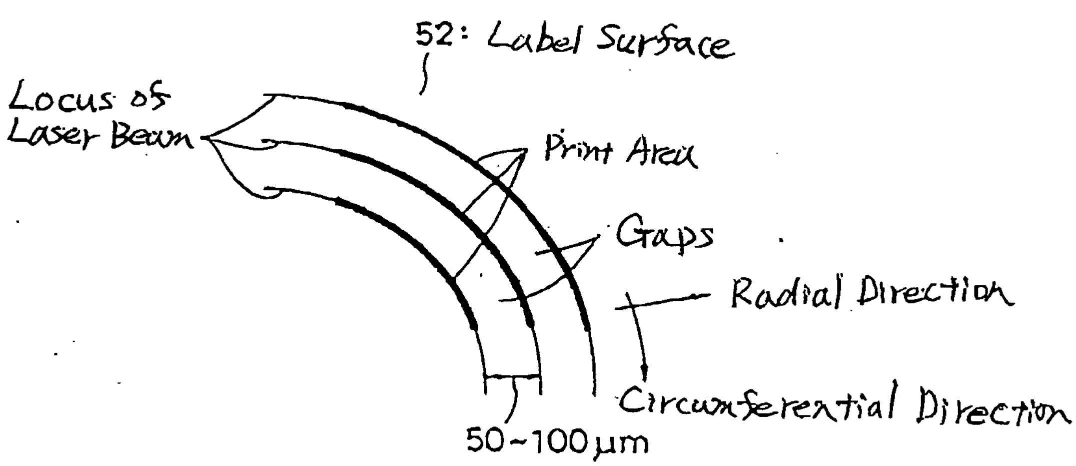

Radius r1
"H"
"L"
Radius r1+Δr
"H"
"L"
Radius r+2Δr
"H"
"L"
One Rotation
Reference Position
"H": High Laser Power
"L": Low Laser Power
Circumferential Position

FIG. 9


52: Label Surface
Locus of Laser Beam
Print Area
Gaps
Radial Direction
Circumferential Direction
50~100μm

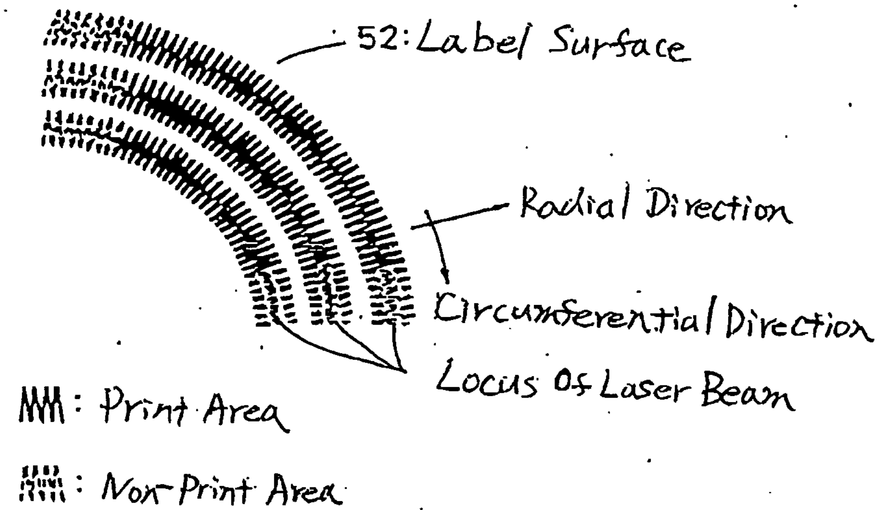

52: Label Surface
Radial Direction
Circumferential Direction
Locus Of Laser Beam
: Print Area
: Non-Print Area

FIG. 10

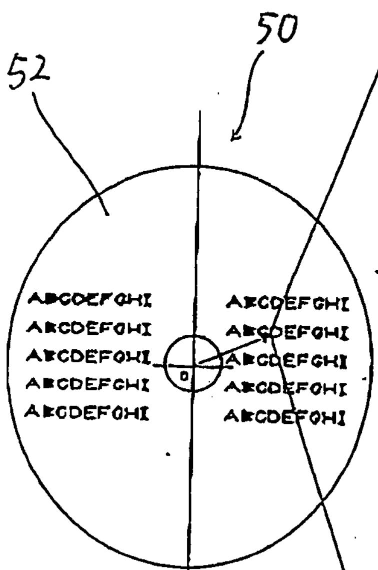


Fig. 11A

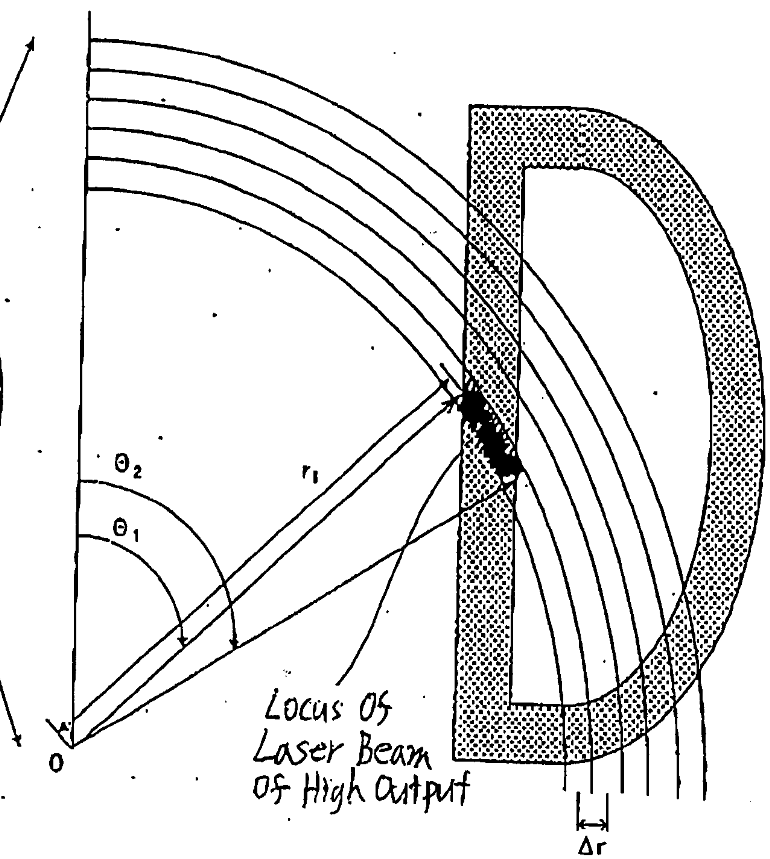


Fig. 11B

Fig. 12A

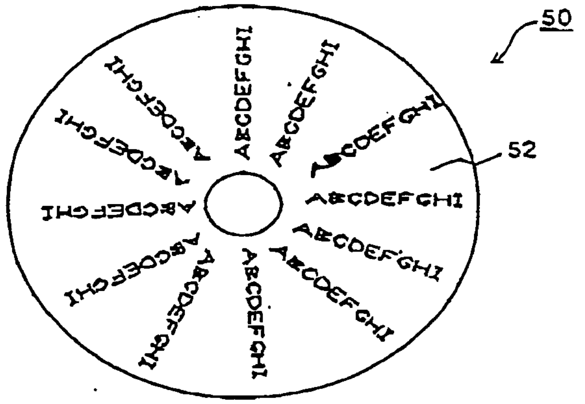


Fig. 12B

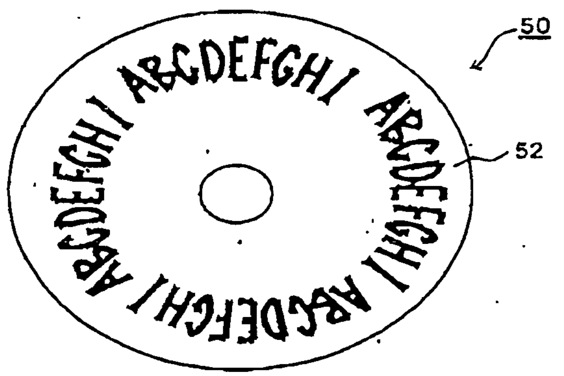


Fig. 12C

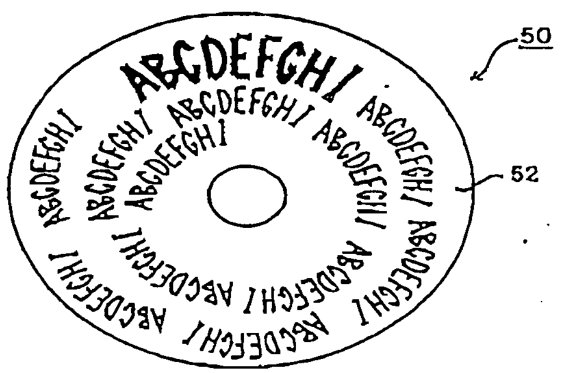
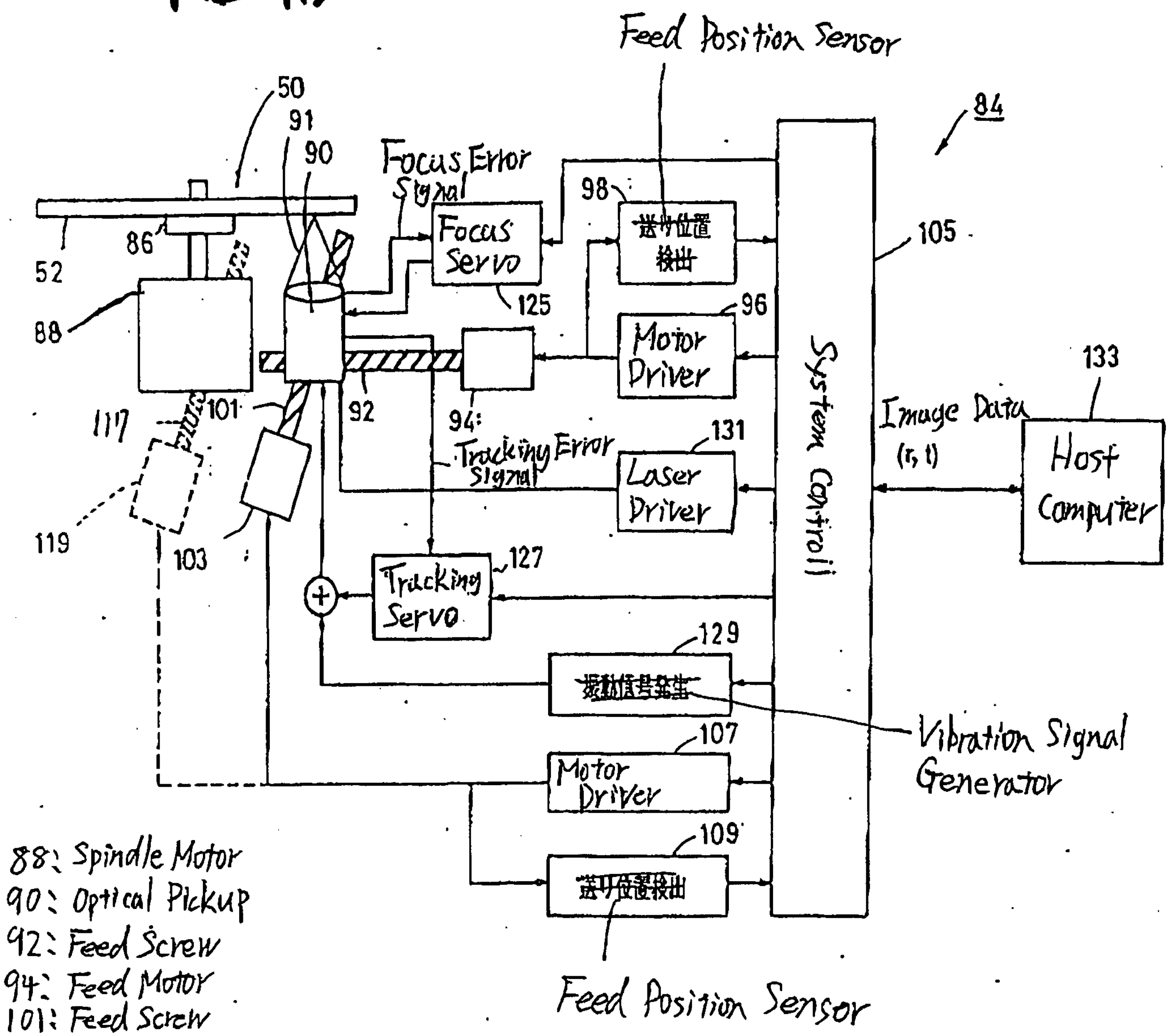


FIG.13



88: Spindle Motor
90: Optical Pickup
92: Feed Screw
94: Feed Motor
101: Feed Screw
103: Feed Motor
117: Feed Screw
119: Feed Motor

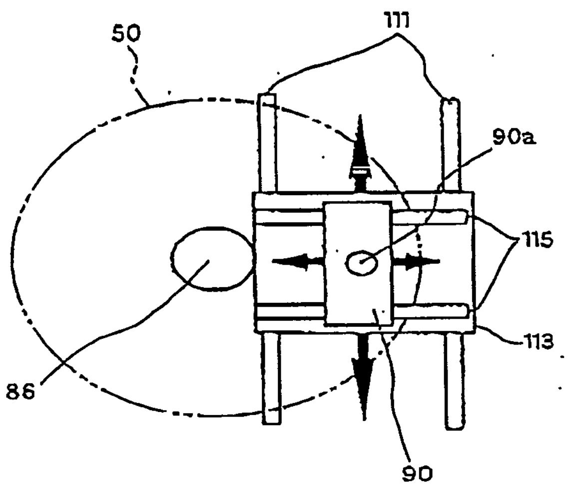


FIG.14A

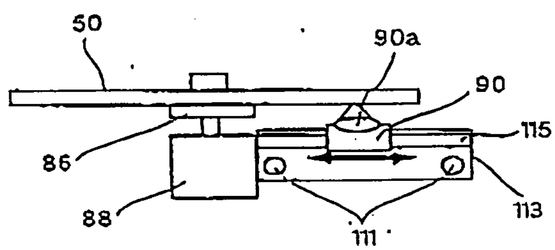


FIG.14B

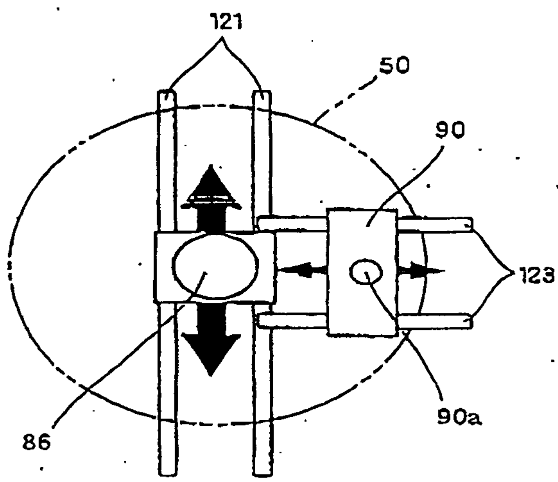


FIG. 15A

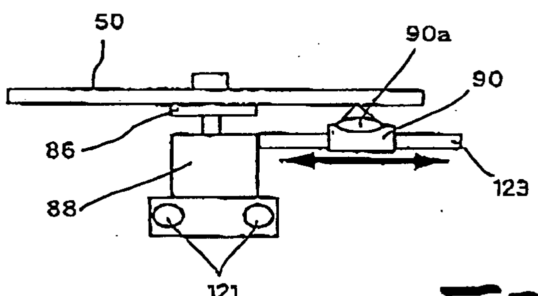


FIG. 15B

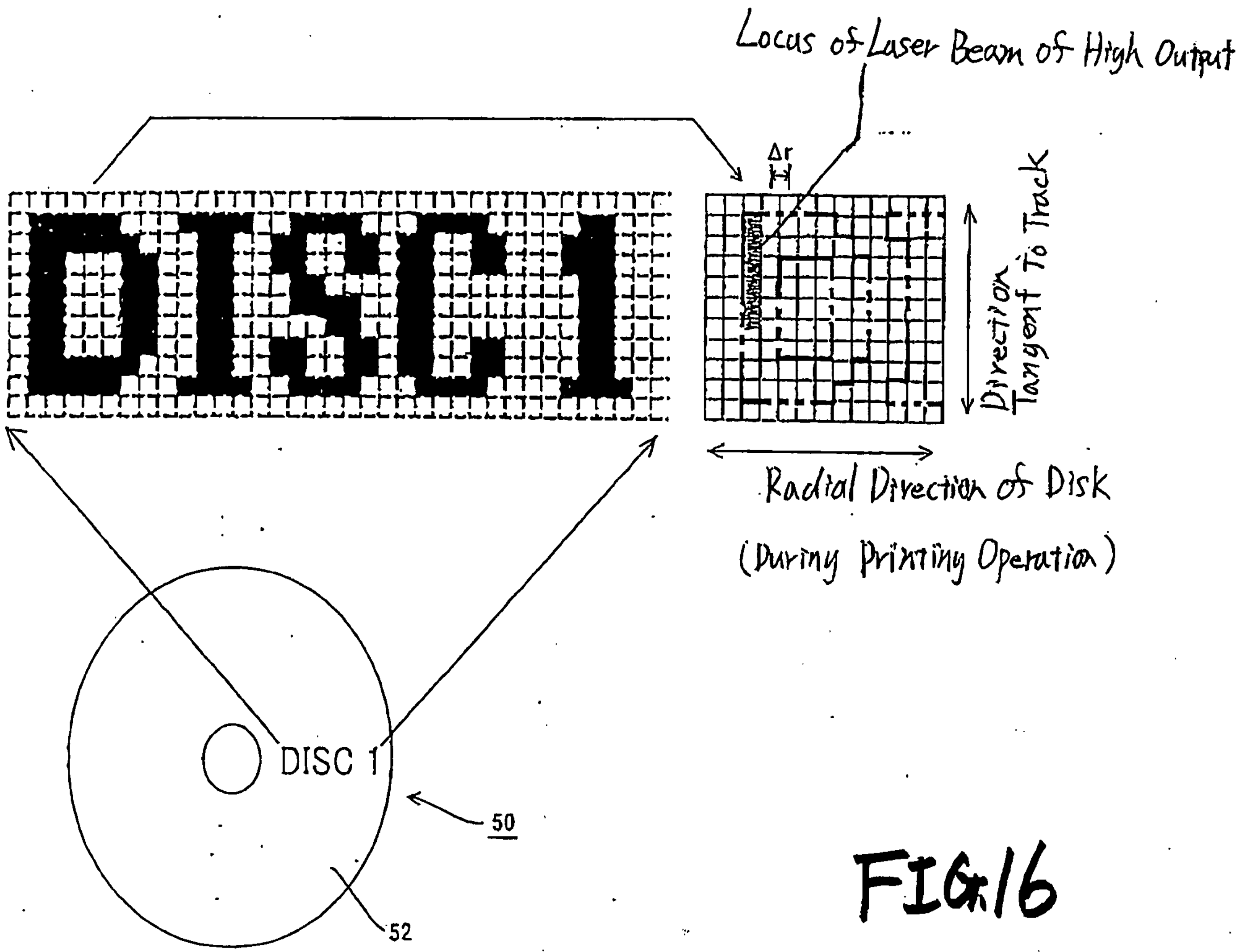

Locus of Laser Beam of High Output
Δr
Direction Tangent To Track
Radial Direction of Disk
(During Printing Operation)
DISC 1
50
52

FIG16